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ABSTRACT

Utilizing 1990 and 1996 National Assessment of Educational Progress data regarding mathematics achievement, students' backgrounds, and mathematics teacher practices, this paper examines race and SES (socioeconomic status) related disparities in student performance, beliefs about mathematics, and classroom experiences. Although overall mathematics achievement increased between 1990 and 1996, race- and SES-related gaps were not significantly changed. SES differences appeared to account for some, but not all race-related differences. An examination of classroom practices revealed many similarities in students' experiences that were consistent with the NCTM (National Council of Teachers of Mathematics) Standards, such as group work and manipulative use. However, other aspects of mathematics instruction, such as the role of calculators, type of assessment used, and teacher emphasis on reasoning were found to correlate with both SES and race, and the correlation with race persisted even after controlling for SES. The results suggest that white, middle class students are experiencing more of the fundamental shifts called for in the Standards. However, the paper raises cautions about concluding that such instructional differences are causing the race- and SES-related gaps in achievement. The findings emphasize the need to find ways of enhancing the mathematical problem solving skills of lower-SES and African American students. (Contains 23 references and 5 tables.) (Author/MM)

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Are the NCTM *Standards* reaching all students? An examination of race, class, and instructional practices

Paper presented at the annual meeting of the
American Educational Research Association, Seattle, 2001

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Abstract

Utilizing 1990 and 1996 National Assessment of Educational Progress data regarding mathematics achievement, students' backgrounds, and mathematics teacher practices, the author examined race- and SES-related disparities in student performance, beliefs about mathematics, and classroom experiences. Although overall mathematics achievement increased between 1990 and 1996, race- and SES-related gaps were not significantly changed. SES differences appeared to account for some, but not all race-related differences. An examination of classroom practices revealed many similarities in students' experiences that were consistent with the NCTM *Standards*, such as group work and manipulative use. However, other aspects of mathematics instruction, such as the role of calculators, type of assessment used, and teacher emphasis on reasoning were found to correlate with both SES and race, and the correlation with race persisted even after controlling for SES. The results suggest that White, middle-class students are experiencing more of the fundamental shifts called for in the *Standards*. However, the author raises cautions about concluding that such instructional differences are causing the race- and SES-related gaps in achievement. The findings emphasize the need to find ways of enhancing the mathematical problem solving skills of lower-SES and African American students.

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Introduction

Mathematics serves as a "critical filter" in our society, with the potential to reward successful students with high occupational status and pay (Campbell, 1991). Not only can mathematics achievement serve as a ladder of economic mobility, it is also essential for making informed consumer and voter choices. The National Council of Teachers of Mathematics (NCTM, 1989; 1991; 2000) has called for "mathematical power for *all*" including for students traditionally under-represented in mathematics-related careers.

NCTM's vision of mathematics instruction centers around problem solving, sense making, and discussion. In important ways, this vision sounds promising for promoting equity. For example, several researchers have noted that students of lower socioeconomic status (SES)[1] and minority groups have received more than their share of rote learning and low-level exercises from teachers who expect little of them (e.g., Anyon, 1981; Knapp, Shields, & Turnbull, 1995; Means & Knapp, 1991). This pattern would seem to perpetuate inequities, with higher-SES students being educated to be leaders, while lower SES students are trained to be followers. Moreover, some scholars argue that African-American students tend to prefer working in more relational, holistic ways, as opposed to memorizing and following rigid rules in isolation (Stiff, 1990). Hence, the current reforms challenge the status quo and seem to hold promise, not simply for "all students," but particularly for lower-SES and African American students.

As early as 1993, over half of the states in the U.S. had changed their testing programs or curriculum recommendations in light of the *Standards* (Usiskin, 1993). Still, one wonders if the influence of the *Standards*, is, indeed, reaching all students.

One way to explore the *Standards'* effects on both students' experiences and achievement is to examine data from the National Assessment of Educational Progress (NAEP). The NAEP is the only nationally representative, ongoing assessment of academic achievement in the United States. The NAEP measures student performance at 4th, 8th, and 12th grades in mathematics and other subject areas. Although its primary aim is to monitor achievement outcomes, the NAEP also provides data from students and teachers about a variety of instructional issues, such as the use of technology, manipulatives, curricular materials, and beliefs about mathematics and

[1] Socioeconomic status can be thought of as an approximation for social class, which connotes more permanence, shared group values, and beliefs about roles in society and relationship to power (Secada, 1992).

mathematics teaching. Beginning in 1990, the framework for the NAEP's main mathematics assessment was heavily influenced by NCTM's *Curriculum and Evaluation Standards* (1989). The *Standards* shaped the development of the 1990 and subsequent NAEP achievement test items and instruction-related background questions.[2]

As early as 1992, changes in NAEP mathematics scores were attributed by some to the NCTM *Standards*. For example, in an NCTM *Bulletin* article entitled, "NAEP Results Show Improvement," then Secretary of State, Lamar Alexander, credited the NCTM reforms for the "improved" scores (NCTM, 1993). But a closer look at the fine print in the article revealed that, although White students' scores had increased at all three grade levels tested, African American and Hispanic students' scores were up only at the 12th grade level. Moreover, there was a significant decline in the average proficiency of eighth graders from "disadvantaged, urban areas."

More recent NAEP achievement data continue to reveal large gaps between White and African-American students, as well as between socio-economically advantaged and disadvantaged students. Several recent reports have summarized various facets of the 1996 NAEP mathematics results (e.g., Kenney & Silver, 2000; Mitchell, Hawkins, Jakwerth, Stancavage, & Dossey, 1999). These documents give attention to equity by reporting classroom practices and achievement results by isolated categories, such as race, gender, parent education level and home literacy resources. Such NAEP reports tend to acknowledge the conflation of race and class in the results, but do not disentangle these factors.

Despite the large race- and class-based achievement gaps, mathematics education researchers have given little attention to the classroom processes that might contribute to these gaps. Indeed, in a survey of 1,543 journal articles published in mathematics education research journals, Lubienski and Bowen (2000) found only 35 relating to ethnicity and 11 relating to social class; the majority of these equity-related articles focused on achievement outcomes, as opposed to the processes contributing to those outcomes.

Given the *Standards'* emphasis on mathematical power for all students, it is particularly important to monitor equity-related achievement and instructional gaps as *Standards*-based

[2] There are two different NAEP mathematics assessments: the main assessment and the long-term trend assessment. The framework that determines the content of the main assessment is responsive to national trends, such as the recent emphasis on the NCTM *Standards*. The long-term trend assessment was created in 1973 and has remained constant over time. The long-term trend assessment was most recently administered in 1999, whereas the main assessment was administered in 1996 and again in 2000 (the raw data from the 2000 assessment will not be available to researchers until late 2001.)

practices are implemented. This study goes beyond previously published NAEP reports by examining race and SES together, with an eye toward disparities in classroom practices.

Method

This study utilized 1990 and 1996 NAEP data to examine disparities in students' mathematics classroom experiences, with attention to both race and SES. These two assessments were chosen because 1990 was the first assessment aligned with the NCTM *Standards*, and 1996 is the most recent (for which data are available).

NAEP samples consist of several thousand 4th, 8th and 12th graders from both public and private schools. Although the NAEP's main focus is academic achievement, the students, their teachers and administrators complete detailed questionnaires pertaining to a variety of background variables, including students' attitudes and study habits, teachers' instructional emphases, and school policies.

There are several features that make NAEP data particularly difficult to analyze. These features include the use of multi-staged, stratified random sampling (in which geographic areas, then schools and then students are selected), the oversampling of private school and minority students, and the use of plausible values to estimate scores for each student based on his/her background and performance on a subset of items. For more information about these statistical issues, see Johnson (1992) or Johnson and Rust (1992). The special weighting and jackknifing needs of NAEP analyses are addressed by a special software program called NAEPEX (that works in conjunction with SPSS), designed by the Educational Testing Service.

In this study, NAEPEX software was used to extract and create SPSS code for relevant variables from the 1990 and 1996 main mathematics NAEP data sets. Variables included were those that pertained to students' mathematics achievement, demographics, attitudes, behaviors, as well as teachers' backgrounds and instructional philosophies.

NAEP uses students' self-reports (or when this information is missing, school records) to categorize students' race as one of the following: White, African American, Hispanic, Asian/Pacific Islander, and American Indian (including Alaskan Native). Analyses of race reported here involve comparisons between White and African American students only. This relatively narrow focus is due to both recent concerns about the growth in the gap between African American and White students' achievement (e.g., Jencks & Phillips, 1998), as well as a

concern about NAEP sample sizes for other minority groups becoming too small when examined in conjunction with SES.

In order to examine trends relating to SES across the 1990 and 1996 data, I constructed an SES variable using the two most relevant variables present in both data sets: resources in the home (books, encyclopedia, magazines, newspapers) and parental education. The ideal would have been to create a continuous SES variable, but both variables were discrete and contained only 3-4 values. Parental education information is not reported for about one third of 4th graders, posing yet another difficulty. After considering both the much-debated meaning of "socioeconomic status" and the percentages of students in each cell of Table 1 across 4th, 8th and 12th grades for both 1990 and 1996, I assigned students to an "SES quartile" as follows:

Table 1: SES Quartile[1] Assignments

Resources in the Home	Did not finish high school	Finished high school	Some post-high school education	College degree	Parent education missing
0-2 Resources[2]	1st quartile	1st quartile	2nd quartile	2nd quartile	1st quartile
3 Resources	1st quartile	1st quartile	2nd quartile	3rd quartile	2nd quartile
4 Resources	1st quartile	2nd quartile	3rd quartile	4th quartile	3rd quartile
Home Resources missing[3]	1st quartile	1st quartile	2nd quartile	3rd quartile	missing SES

Table Notes:

1) I refer to the four categories as "quartiles," although the actual percentage of students in each group varied, depending on the year and grade level.
2) So few students report having less than 2 of the 4 resources in the home, that NAEP collapses the categories to be 0-2 items, 3 items or 4 items. "Parent Education" refers to the higher of either the mother or father when they differ.
3) When either parent education or home environment information was missing, I assigned the student to the SES quartile that he/she was most likely to be in, given the value of the remaining variable. If a student's parent education and home environment information was missing, the student was excluded from SES-based analyses.

Figure 1 reports the NAEP sample sizes, as well as the percentage of African American and White students in each SES quartile. As Figure 1 reveals, higher proportions of White students were in the higher SES quartiles, whereas higher proportions of African American students were

in the lower quartiles. However, the figure also reports a positive trend of slightly more White and African American students in the higher quartiles in 1996 than in 1990. Still, the substantial SES disparities between White and African American students remained.

Figure 1: 1990 and 1996 Percentages of White and African American Students In Each SES Quartile

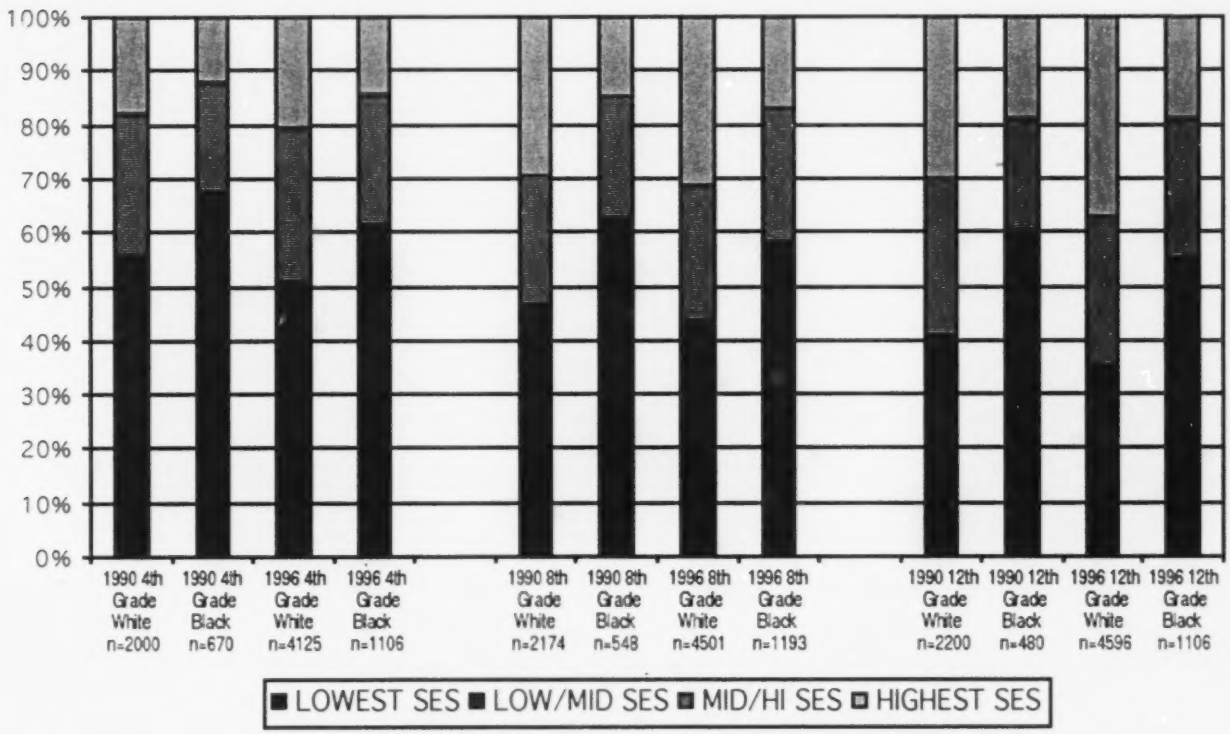


Figure Note: These numbers are the unweighted sample sizes. In 1990, African American students were weighted as roughly 15% of the population (the percentage varies slightly depending on the grade level), and in 1996 were weighted as roughly 14%. White students were weighted as roughly 71% of the population in 1990 and 69% in 1996. (Hispanic student weight increased from about 9% in 1990 to 12% in 1996.)

Data analyses involved computing 4th, 8th, and 12th grade means and standard errors for student and teacher questionnaire data. Means were compared across SES and ethnic groups (including intersections between them) with a focus on disparities in instructional practices, as well as some attention to changes in practices between 1990 and 1996.

Results

An in-depth analysis of NAEP mathematics achievement trends, with attention to interactions among race, SES, and gender, are discussed in a separate paper (Lubienski, 2001). However, to set the stage for this discussion of instructional practices, a few highlights regarding achievement are noted here.

General Mathematics Achievement: 1990 To 1996

Although the findings I discuss here tend to point toward areas of concern, there are important positive findings to be noted. First and foremost, overall achievement scores increased between 1990 and 1996 in every grade for every mathematical strand (number and operations, geometry, measurement, data analysis/statistics, and algebra/functions). When disparities between African American and White students have worsened, this is generally because the gains of White students were larger than the gains of African American students. Additionally, there are ways in which the achievement and teacher emphases for some strands — especially algebra and geometry — have become more uniform across groups. For example, in 1990 White fourth graders were more likely than African American fourth graders to have a teacher who reported giving significant emphases to algebra, but that gap had closed in 1996.

Despite the overall good news, there continue to be significant[3] gaps between African American and White students, as well between low- and high-SES students (See Table 2). In order to help the reader interpret the results, some information about the NAEP achievement scale is necessary. NAEP uses a consistent 500 point scale on which 1996 4th graders scored an average of 224 and 12th graders scored an average of 304. Hence, a 10-point achievement gap can be thought of roughly as a one-year difference.

[3] Unless otherwise noted, conclusions about significant differences reported in this paper were determined using a 2-tailed test, with $p < .05$. Multiple comparisons were not accounted for when determining significance. Hence, the results reported here should be interpreted with care.

Table 2: 1990 - 1996 Mean Achievement by Race and SES

	Fourth Grade			Eighth Grade			Twelfth Grade		
	All Quartiles	Lowest SES Quartile	Highest SES Quartile	All Quartiles	Lowest SES Quartile	Highest SES Quartile	All Quartiles	Lowest SES Quartile	Highest SES Quartile
1990									
White	220 (1.1)	211 (1.2)	234 (2.0)	270 (1.4)	251 (1.9)	284 (1.5)	301 (1.2)	280 (2.4)	313 (1.7)
African American	189 (1.8)	184 (2.6)	197 (3.5)	238 (2.7)	228 (3.2)	251 (4.3)	268 (1.9)	260 (3.1)	277 (3.8)
1996									
White	232 (.9) *+ 12*	222 (1.7) *+11*	245 (1.3) *+11*	282 (1.2) +12	265 (1.7) *+14*	293 (1.5) *+9*	311 (1.0) +11	295 (1.4) *+15*	319 (1.1) *+6*
African American	200 (2.3) *+ 11*	192 (2.2) *+ 8*	206 (4.5) *+9*	243 (2.0) +5	233 (2.0) *+5*	252 (2.3) *+1*	280 (2.2) +12	269 (2.1) *+9*	290 (4.3) *+13*
Current African American/ White Gap	32	30	39	39	32	41	31	26	29
Change in African American/ White Gap since 90	*+ 1*	*+ 3*	*+ 2*	*+ 7*	*+ 9*	*+ 8*	*-1*	*+ 6*	*-7*

Table Notes: Standard errors are in parentheses. To simplify the detailed nature of this information, all achievement scores have been rounded to the nearest integer. Changes from 1990 to 1996 are noted in italics. The 1990 and 1996 African American/White gaps for each grade level are significant, but the changes in the gaps are not.

In 1996, the African American-White gap was 32 points at fourth grade (up from 31 points in 1990), 39 points at 8th grade (up from 32 points in 1990), and 31 points at 12th grade (down 1 point since 1990). To put some perspective on the severity of these differences, note that the average score of African American 12th graders was lower than that of White 8th graders. Gaps between the lowest and highest SES quartiles were slightly smaller than the African American-White gaps: an average of 25 points (down from 30 in 1990) for White students, and only 18 points for African American students (unchanged since 1990).

One might wonder if the African American-White gap is primarily about class differences rather than race. Although class is certainly a factor, the short answer appears to be "no." Consistently across the three grades in both 1990 and 1996, the *lowest*-SES White students

scored equal to or higher (often significantly so) than the *highest*-SES African American students.[4]

More details about disparities in student performance by mathematical strand and question type are discussed in Lubienski (2001), as well as in Strutchens and Silver (2000) and Mitchell, Hawkins, Stancavage, and Dossey (1999). These reports indicate that race- and SES-related disparities are particularly large on open-ended items (as opposed to multiple choice items). Not only do relatively few African American and lower-SES children answer open ended questions correctly, these children are also much more likely to completely omit such items. As a fairly typical example of an open-ended problem, one 8th grade problem involved fencing a dog pen with 36 feet of fence. Students were asked to find the dimensions of a rectangular yard that would give the maximum area. 34% of White students compared with 10% of African American students gave responses that were at least partially correct. Moreover, 45% of African American students, compared with 21% of White students omitted the problem completely.

NAEP data on students' and teachers' mathematical practices and beliefs

The NAEP is not longitudinal nor designed for making cause-and-effect inferences regarding instructional methods and student outcomes. However, analyses of NAEP student and teacher questionnaires can reveal similarities and differences in students' classroom experiences and attitudes, comparing those that currently exist with those envisioned in the NCTM *Standards*. Such an analysis sheds light on factors that could shape the achievement differences noted above.

Strutchens and Silver (2000) recently summarized the 1996 NAEP data pertaining to race-related patterns in students' classroom experiences, attitudes and beliefs. In this section, I draw from their analyses as I explore factors that do or do not correlate with the achievement disparities noted above. For those factors that appear to correlate with African American-White achievement differences, I go beyond Strutchens and Silver's race-focused analyses to consider SES-based differences, as well as interactions between race and SES. I begin broadly by

[4] Recall that I did not include school lunch eligibility as a factor in determining SES. This variable was not available in the 1990 data set. Using the 1996 data only, I reanalyzed this particular pattern (low-SES White students versus high-SES African American students) using a "stronger" SES variable based on the SES quartiles as defined previously, combined with school lunch eligibility. In doing so, the pattern weakened somewhat, so that the highest-SES African American students scored slightly (not significantly) higher than the lowest-SES White students at each grade level. However, it is important to note that the SES groups under consideration were smaller in size than in the original analysis, with each group now representing less than 10% of each ethnic group.

examining general factors relating to students' actions and attitudes, such as student course taking and time spent on homework. Then I focus more specifically on classroom-related practices, particularly those advocated by NCTM.

Student Course Taking

According to Strutchens and Silver (2000), both African American and White seniors reported taking more mathematics in 1996 than in 1990 or 1992. Additionally, the African American-White gaps in algebra and geometry course-taking narrowed. However, there continue to be differences in pre-calculus and calculus enrollment. In 1996, 7% of African American students, compared with 13% of White students reported taking calculus, and 25% of White seniors, compared with 17% of African American seniors took pre-calculus. The African American-White gaps for these courses have not improved since 1992.

Yet overall, course taking gaps appear to be more related to SES than race. For example, although there are significant gaps between the percentage of lower- and higher-SES 12th graders who reported taking algebra before 9th grade, there are only slight, insignificant gaps between African American and White students within each SES category. This fact, in addition to the fact that course-taking differences are more present in high school than 4th and 8th grades, leads one to conclude that course-taking differences exist, but leave much of the African American-White achievement gap unexplained.

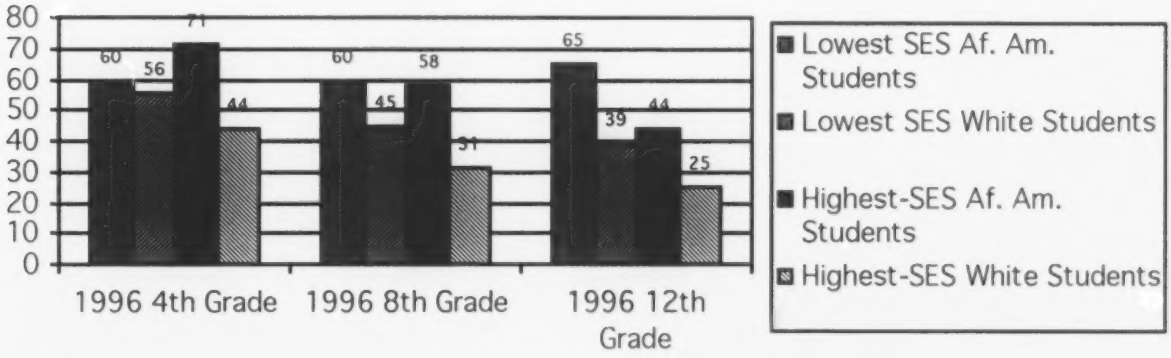
Student Behaviors & Beliefs

On the 1996 NAEP survey, students were asked how much time they spend on homework, as well as about their attitudes toward mathematics, including whether they like the subject and believe it is useful. These factors do seem to help explain the African American/White achievement gaps in mathematics. For example, African American students report spending at least as much time on homework as White students. (However, low-SES students reported spending slightly less time on homework than their high-SES peers.) African American students report liking mathematics and believing it is useful at least as much as White students. Furthermore, students' beliefs about the correlation between effort and achievement do not explain the gap. In 1996, 31% of White 8th graders versus 59% of African American 8th graders "strongly agreed" with the statement, "All can do well in math if they try."

Still, there are some differences in students' beliefs that could be related to the mathematics achievement differences, and might also suggest differences in access to NCTM-based instructional practices. African American fourth graders (27%) were significantly more likely than White (13%) fourth graders to agree that there is only one way to solve a math problem. At eighth grade, the percentages were 12% for African American students and 6% for White students (not statistically significant). This pattern was stronger for race than for SES.

Similarly, lower-SES and African American students were more likely than White and upper-SES students to agree with the statement, "Learning mathematics is mostly memorizing facts" (see Figure 2). Although students generally appear to move away from this belief as they move through school, the African American-White and SES gaps grow as students are in school, and the gaps are larger between African American and White students than between the lowest and highest SES students. Additionally, although this view was strongly tied to SES for White students (with higher-SES students less likely to view math as memorization), the belief persisted across all SES levels for African American 4th and 8th graders. At each grade level, a larger percentage of high-SES African American students than low-SES White students agreed that mathematics learning is primarily fact memorization. Overall, by 12th grade, only 29% of White students agreed, but 55% of African American students agreed.

Figure 2: Percentage of students agreeing with the statement, "Learning mathematics is mostly memorizing facts."[5]



One possible explanation for these differences in student beliefs is that African American and White students could be receiving different forms of mathematics instruction. The following section explores this hypothesis further.

Instructional Practices

NCTM is promoting new instructional methods to be used with *all* students. A major thrust of NCTM's initiative is to help students view mathematics in terms of problem solving and sense making. The fact that almost two thirds of African American 4th graders and over half of African American 12th graders viewed mathematics learning as memorization suggests that perhaps the NCTM reforms are being implemented more with some student populations than others.

NAEP data on 4th and 8th grade teachers' instructional practices shed some light on this subject. (12th grade teachers were not surveyed about their instructional practices.) First, there are a number of areas in which high-SES or White students do <u>not</u> appear to be experiencing Standards-based instruction substantially more than low-SES or African American students.

[5] At the 4th and 8th grade levels, the overall SES and White-African American differences are significant. The SES differences are significant within White students but not African American students. At the 12th grade level, the overall SES and White-African American differences are significant, as are the SES differences within both White and African-American students.

Briefly, these areas include the regular use of manipulatives, the use of "real-life" mathematics problems, and student collaboration. (See Table 3).

Table 3: 1996 Student and Teacher Responses Regarding Manipulatives, Group Problem Solving, "Real Life" Problems, Instructional Time, and *Standards* Knowledge.

	4th Grade					8th Grade				
Percentage of students who reported:	**Total**	Low SES	High SES	Afr. Am.	White	**Total**	Low SES	High SES	Afr. Am.	White
They work with manipulatives (blocks, shapes, rulers) at least weekly	**41**	44	41	48	39	**25**	24	27	25	22
They solve problems with a partner or group at least weekly	**48**	44	52	55	46	**44**	43	46	52	41
Percentage of students whose teachers reported:										
Having students work "real life" mathematics problems at least weekly.	**73**	75	73	77	73	**74**	75	73	74	74
Spending 4 or more hours per week on math instruction	**68**	71	65	78	64	**33**	33	37	44	31
Being at least "somewhat knowledgeable" about the NCTM *Standards*[6]	**54**	52	57	59	54	**81**	81	82	84	81
Having received professional development regarding the NCTM *Standards*	**53**	54	48	49	54	**70**	69	70	74	69

Also, there were no substantial patterns in teachers' reported knowledge about the NCTM *Standards* that correlated with student race or SES. Regardless of SES or race, just over half of the 4th graders and over 80% of the 8th graders had teachers who reported being at least "somewhat knowledgeable" about the NCTM *Standards*.[7] Similarly, approximately half of 4th graders and 70% of 8th graders were taught by teachers who reported receiving professional development regarding the NCTM Standards. However, a closer look at the type of professional development received revealed that White students were more likely than African American

[6] The options for teachers to choose from were "very knowledgeable", "knowledgeable", "somewhat knowledgeable" or "little/no knowledge."

[7] The NAEP sample involves a random sample of students, and not teachers. Therefore, claims must be made at the student, not teacher, level.

students to have teachers who attended an NCTM regional or national meeting. For example, at the 8th grade level, 8% of White students versus 3% of African American students had teachers who attended an NCTM Annual meeting. For a regional meeting, the percentages were 21% for White students and 14% for African Americans. Interestingly, there were no significant similar SES-related patterns.

Additionally, there were no strong SES- or race-related patterns in time spent on mathematics instruction that would help explain the achievement differences discussed above. In fact, the teachers of African American students reported spending more time per week on mathematics instruction than teachers of White students. The most remarkable finding related to time on mathematics instruction is the dramatic drop from 4th to 8th grade in spending "4 or more hours per week on math instruction."

Furthermore, the vast majority of teachers of all children expressed strong agreement with most statements that convey main ideas in the NCTM *Standards*. For example, regardless of race or SES, the teachers of about 90% of 4th graders and 83% of 8th graders said that, "Using problem solving both as a goal of instruction and as a means of investigating important mathematical concepts" was "very important" (as opposed to "somewhat important", "not very important", or "not important"). Similarly, the teachers of about 86% of 4th graders and between 75% and 85%[8] of 8th graders said that, "Using questioning techniques that promote student interaction and discussion" was "very important."

Hence, there are ways in which NCTM-based instructional practices seem to be just as prevalent in classrooms with low-SES and African American students, at least on the surface. However, other NAEP evidence suggests that White and higher-SES students are experiencing more of the fundamental shifts called for by NCTM.

Multiple Choice Assessments

Although most teachers reported that they do not use multiple choice tests often, 4th grade African American students of all SES levels were more likely than White students to be assessed with multiple choice assessments. For example, the teachers of 44% of White, versus 65% of African American 4th graders reported using multiple choice assessments at least monthly. High-SES White 4th graders were less likely to have multiple choice tests than their low-SES

counterparts, but SES patterns were absent for African American 4th graders, with over 60% of African American students at each SES level experiencing regular multiple choice tests. SES and African American-White disparities were smaller but still present at the 8th grade level.

Technology Use

Another area in which race- and SES-related differences appear is technology use. Although teachers of African American students report having as much access to technology as those of White students, there appear to be differences in the uses of technology. For example, although African American 8th graders appear more likely than White 8th graders to use computers in math class, this usage is most often for drill and practice or games, whereas White students are more likely to have computers used for simulations, demonstrations or applications of concepts. This pattern was not significantly related to SES. Additionally, although calculator use has dramatically increased since 1990, African-American 8th graders are still significantly less likely to be given access to them as a regular part of mathematics instruction or assessment (see Table 4). For example, in 1996, 61% of White 8th grade students, compared with 32% of African Americans had a teacher who reported students using calculators "almost every day." Similarly, 72% of White students, compared with 51% of African American students had teachers who reported allowing the use of calculators on tests. These gaps between White and African American students increased between 1990 and 1996, and are slightly larger than the gaps between the lowest and highest SES quartiles. In both cases, the 1996 African American-White differences are not simply attributable to student SES differences, as the highest SES quartile of African American students had teachers who allowed less calculator access than teachers of the lowest-SES quartile of White students.

[8] There were slight SES- and race-related patterns at the 8th grade level, with white and higher-SES students more likely to have teachers who emphasized this.

Table 4: 8th Grade Calculator Use by Race/SES

	Percentage of 8th graders whose teachers responded "almost every day" to "How often do students use a calculator?"		Percentage of 8th graders whose teachers responded "yes" to "Do you permit the use of calculators on tests?"	
	1990 8th Grade	1996 8th Grade	1990 8th Grade	1996 8th Grade
Lowest-SES African American Students	6	28	11	43
Lowest-SES White Students	6	51	25	62
Highest-SES African American Students	10	41	25	56
Highest-SES White students	21	65	40	78

Table Notes: The percentages given are row percents. For example, in 1990, 6% of African American students had teachers who allowed calculator use "almost every day."
For both calculator-related variables, the 1996 overall SES and race-related differences are significant. The SES difference within White students is also significant, but the SES difference within African American students is not. (The relatively small sample of African American students is a factor here.)

Teacher Emphases

As part of the 1996 NAEP, teachers were asked about the emphasis they place on each of the 5 mathematics strands. The scale teachers were given to indicate their emphasis had four options: 1 = A lot of emphasis, 2 = some emphasis, 3 = a little emphasis, or 4 = none. At the 4th grade level, there was remarkable consistency across SES and racial groups in terms of the emphasis teachers reported giving to each strand.[9] Regardless of student SES or race, number received the most emphasis of the 5 mathematics strands (mean of 1.07) and Algebra received the least (mean of 2.73). (See Table 5) A comparison with similar data from 1990 revealed that the overall emphasis on 4th grade algebra significantly increased (from 3.26 to 2.73). Furthermore, teacher emphasis on algebra was greater for White 4th graders than African American 4th graders in 1990, but this gap had closed in 1996.

[9] Still, substantial differences in instructional emphases might be masked in these data. The 4 point scale is rough and perhaps insensitive to actual differences in teacher emphases. Also, the NAEP surveys do not delineate the particular topics taught within each strand.

At the 8th grade level, there was, again, much consistency in teachers' reported emphases on most topics. However, teachers of lower-SES and African American 8th graders reported giving significantly less emphasis to algebra and "reasoning to solve unique problems."

Table 5: Mean Emphasis Teachers Reported Giving To Mathematical Strands and Other Topics, 1996

	Number	Msmt.	Geo.	Data	Algebra	Facts	Skills	Reasoning	Communication
4th Grade Overall	1.07	1.98	2.20	2.51	2.73	1.07	1.09	1.57	1.82
8th Grade Overall	1.14	2.05	2.01	2.30	1.54	1.27	1.25	1.56	1.73
8th Grade Af. Am.	1.14	2.05	2.01	2.28	**1.70**	1.25	1.17	**1.71**	1.67
8th Grade White	1.14	2.05	2.01	2.31	**1.49**	1.26	1.25	**1.51**	1.74
8th Grade Low SES	1.13	2.01	1.97	2.32	**1.67**	1.29	1.23	**1.69**	1.83
8th Grade High SES	1.16	2.1	2.06	2.29	**1.40**	1.28	1.25	**1.49**	1.69

Table notes: The SES- and race-related differences are significant for both algebra and reasoning.

Discussion

This analyses uncovered more similarities than differences in students' mathematics classroom experiences, with few SES- or race-related gaps found in the use of manipulatives, "real-life" mathematics problems, student collaboration, and time spent on homework or math instruction. Additionally, few differences were found in teachers' reported preparation in and knowledge of the NCTM *Standards*, or in their reported agreement with, and emphasis on, many central tenants of the *Standards*.

Still, this study identified some differences that could underlie some SES- and race-related achievement disparities. Student course taking is likely a factor, but appears more related to SES than race, and therefore leaves much of the African American-White achievement gap unexplained. Factors correlating with both SES and race that persist for race even after controlling for SES include students' belief that there is only one way to solve a math problem, the belief that learning mathematics is mostly memorizing facts, the use of computers for skill practice or games, limited calculator use, multiple choice assessment use, and lack of teacher emphasis on "reasoning to solve unique problems." Although these facets might appear minor when compared with the many similarities reported in classroom practices, these differences in both student beliefs and experiences suggest a consistent pattern of lower-SES and African American children tending to be taught (and assessed) with an emphasis on low-level skills.

These findings recall Anyon's (1981) study in which lower-SES students were found to receive more authoritative, drill-based instruction, whereas higher-SES students were taught the problem solving and critical thinking skills necessary for leadership roles in society. The reasons for SES- and race-related differences in student beliefs and classroom experiences, as well as the effects of these differences, require further research.

There are several limitations of this analysis. One potential underlying factor of race-related differences discussed here is school-level SES. Perhaps more mid-SES African American students are in relatively low-SES schools, and, therefore, some race-related differences that persist after controlling for student SES might be due to school SES. Another important caveat to note is that NAEP classroom practice data are based on teacher and student self-reports, and differences in question interpretations or perceived pressure to portray instruction in particular ways could have affected student and teacher responses to questions. Also, the instructional practices reported for each student are only those the student is encountering at the time the NAEP assessment is administered. (Hence, students' experiences in previous years with other teachers are not reflected in the NAEP classroom practice data.)

Therefore, although White and higher-SES students appear to have more of the beliefs and classroom experiences promoted by the NCTM Standards, we cannot conclude from NAEP data that Standards-based experiences are the *cause* of their higher achievement. One alternative explanation is that teachers are more likely to implement *Standards*-based practices with higher achieving students or with students from particular cultural backgrounds. Administrative

support for teachers, teacher expectations of students, community expectations of teachers, and student resistance to particular instructional methods could all be factors in determining which students receive *Standards*-based instruction.

Clearly, low-SES and African American students' relatively high omit and failure rates on open-ended assessment items suggest that these students need more opportunities to develop complex problem solving skills. Indeed, Strutchens and Silver (2000) concluded that 1996 African American 8th graders performed only about 20% as well as White students on extended constructed-response tasks, while performing about 70% as well as White students on multiple-choice questions.[10] They raise the important possibility that we could see continued widening of the African American/White gap as complex, extended tasks become more prevalent on standardized assessments. In fact, this is one plausible explanation for why some African American-White gaps have begun to widen slightly in the last decade. However, we cannot assume that if *Standards*-based instruction were to, indeed, reach all students, then equity would be achieved. Elsewhere I have written about struggles faced by lower-SES students attempting to learn mathematics through problem solving and whole-class discussion (Lubienski, 2000a; 2000b). Although most of the students studied were White, the results raise questions about similar struggles that African American students might face with more open mathematics environments. Delpit (1986) raised similar issues in literacy education. Hence, in our efforts to implement *Standards*-based curricula and pedagogies, we must give attention to the special strengths and needs of poor or minority students. Addressing achievement gaps will involve further research on ways in which cultural issues involving social class, ethnicity, and gender relate to mathematics teaching and learning, as well ways in which exemplary teachers are able to adapt *Standards*-based instructional approaches to meet their students' needs (Lubienski, 2000a; 2000b).

With NCTM's (2000) recent affirmation of its vision of mathematical power for all, it is particularly important that researchers continue to monitor and seek to address inequities in both outcomes and instructional practices that relate to such outcomes. The NAEP offers one avenue for examining disparities in achievement, student/teacher attitudes, and classroom practices. The patterns identified in this study set the stage for a more thorough examination of 2000 NAEP data, scheduled to be released later this year.

REFERENCES

Anyon, J. (1981). Social class and school knowledge. Curriculum Inquiry, 11, 3-42.

Campbell, P. B. (1991). So what do we do with the poor, non-White female? Issues of gender, race, and social class in mathematics and equity. Peabody Journal of Education, 66, 95-112.

Delpit, L. D. (1986). Skills and other dilemmas of a progressive Black educator. Harvard Educational Review, 56(4), 379-385.

Jencks, C., & Phillips, P. (Eds.) (1998). The Black-White test score gap. Washington, DC: Brookings Institution Press.

Johnson, E. G. (1992). The design of the National Assessment of Educational Progress. Journal of Educational Measurement, 29(2) 95-110.

Johnson, E. G. & Rust, K. F. (1992). Population inferences and variance estimation for NAEP data. Journal of Educational Statistics, 17(2) 175-190.

Kenney, P. A. & Silver, E. A. (Eds.) (1997). Results from the sixth mathematics assessment of the National Assessment of Educational Progress. Reston, VA: National Council of Teachers of Mathematics.

Knapp, M. S., Shields, P. M., & Turnbull, B. J. (1995). Academic challenge in high-poverty classrooms. Phi Delta Kappan, 76, 770-776.

Lubienski, S. T., & Bowen, A. (2000). Who's Counting? A Survey of Mathematics Education Research 1982-1998. Journal for Research in Mathematics Education, 31(5), 626-633.

Lubienski, S. T. (2000a). A clash of class cultures? Students' experiences in a discussion-intensive seventh-grade mathematics classroom. Elementary School Journal, 100, 377-403.

Lubienski, S. T. (2000b). Problem solving as a means toward "mathematics for all": An exploratory look through a class lens. Journal for Research in Mathematics Education, 31(4), 454-482.

Lubienski, S. T. (2001). A Second Look at Mathematics Achievement Gaps: Intersections of Race, Class, And Gender In NAEP Data. Paper presented at the annual meeting of the American Educational Research Association, Seattle.

Means, B. & Knapp, M. S. (1991). Cognitive approaches to teaching advanced skills to educationally disadvantaged students. Phi Delta Kappan, December, 282-289.

Mitchell, J. H., Hawkins, E. F., Stancavage, F. B., and Dossey, J. A. (1999). Estimation skills, mathematics-in-context, and advanced skills in mathematics, NCES 2000-451. Washington, DC: National Center for Education Statistics.

Mitchell, J. H., Hawkins, E. F., Jakwerth, P., Stancavage, F. B., & Dossey, J. A. (1999). Student work and teacher practices in mathematics, NCES 1999–453. Washington, DC: National Center for Education Statistics.

National Council of Teachers of Mathematics. (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: Author.

National Council of Teachers of Mathematics. (1991). Professional standards for teaching mathematics. Reston, VA: Author.

National Council of Teachers of Mathematics, (1993). NAEP results show improvement. News Bulletin, 12, 1&12.

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[10] These percentages are derived using ratios of correct responses, as opposed to differences in percentages correct.

National Council of Teachers of Mathematics, (2000). Principles and standards for school mathematics. Reston, VA: NCTM.

Secada, W. G. (1992). Race, ethnicity, social class, language, and achievement in mathematics. In D. A. Grouws (Ed.), Handbook of research on mathematics teaching and learning (pp. 623-660). New York: Macmillan.

Stiff, L. (1990). African-American students and the promise of the Curriculum and Evaluation Standards. In T. J. Cooney & C. R. Hirsch (Eds.), Teaching and learning mathematics in the 1990s (Yearbook of the National Council of Teachers of Mathematics, pp. 152-157), Reston, VA: NCTM.

Strutchens, M. E., & Silver, E. A. (2000). NAEP findings regarding race/ethnicity: Students' performance, school experiences, and attitudes and beliefs. In E. A. Silver & P. A. Kenney (Eds.), Results from the seventh mathematics assessment of the National Assessment of Educational Progress. Reston, VA: National Council of Teachers of Mathematics.

Usiskin, Z. (1993). What changes should be made for the second edition of the NCTM *Standards*? University of Chicago School Mathematics Project Newsletter. Winter, 6-11.